



MDA/MP Radar & RF Insertion



August 2005

Report Documentation Page			Form Approved OMB No. 0704-0188	
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>				
1. REPORT DATE 01 AUG 2005	2. REPORT TYPE N/A	3. DATES COVERED -		
4. TITLE AND SUBTITLE MDA/MP Radar & RF Insertion			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Missile Defense Agency			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited				
13. SUPPLEMENTARY NOTES See also ADM202171., The original document contains color images.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 28
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified		



MP MISSION AND FUNCTIONS

Mission Statement

- Responsible To The Director, MDA For BMD System-Wide Producibility And Manufacturing Risk Assessment, Mitigation, And Applications

Functions

- Assess Priority BMDS Risks Related To Producibility, Manufacturing, Quality, Cost, And Schedule
- Assess MDA Technology Programs Applicability To BMDS Needs And Readiness for Transition
- Assess And Report Transition Readiness Using Engineering Manufacturing Readiness Levels (EMRLs) And The Appropriate EMRL Exit Criteria Metrics (CKP) In Concert With The Elements
- Coordinate MDA Industrial Base Policy And Investments
- In Concert With The Elements, Develop Industrial And Manufacturing Investment Strategies For System Affordability And Insertion Of Successive New Capabilities



Innovative Radar RF Sensors and Signal Processing

- Provide subsystem improvements to enhance BMDS radar performance and sensitivity for emerging threats:
 - Demonstrate producibility and reliability of high-power amplifiers (e.g., SiC, GaN, and High-Voltage GaAs).
 - Introduce producible materials and technologies to enhance thermal management.
 - Improve manufacturability of T/R Modules and TRIMMs for cost and schedule.
 - Introduce “Open System” approaches and architecture to prevent parts obsolescence and stimulate competition at the subsystem level.
 - Introduce composite materials to reduce antenna weight, improve transportability.

• Core programs

- RF Micro-electronics packaging
- Wide Bandgap Program
- High Voltage GaAs
- WBG reliability test Program
- Hybrid Opto-Electronic Signal Processor Maturation and Evaluation



Innovative Radar RF Sensors and Signal Processing

- **MDA/MP is engaging with Program Offices to identify technology areas of concern**
 - Focus on SBIR tasks that improve capabilities within 1 to 3 years
 - Continual process
 - Identify new processes
 - Identify new technologies
 - Provide solutions to technology problems
 - Prime and Second and Third Tier contractors are working with us on implementation
- **MDA/MP support of BMDS RADAR acquisition aimed at**
 - Near term technology insertion with demo of producible technologies
 - Tie-in with MDA Primes and 2nd/3rd tier suppliers
- **Program support with core MP funding / SBIRs / STTRs**
 - Device development (WBG, High voltage GaAs)
 - Packaging / Thermal management
 - Reliability testing
 - Product maturity (EMRLs)



MDA/MP Focus

- MDA System/Subsystem Near Term Spiral Development
 - Potential for Near-Term Insertion (1-3 Years)
 - EMRL of 3 or higher
 - Demonstrated Capabilities for Multiple Applications
 - Common Components
- Demonstrate Producibility
 - Best Industry Practices
 - Foster Tie-in with MDA Primes or our large 2nd and 3rd Tier Suppliers
 - Near Term P3I
- Modular Designs for Future Systems

Focus on Leverage / Cost Sharing / “Long Poles”



Innovative Radar RF Sensors and Signal Processing – Core Programs

- **Technical Evaluation of Packaging Technology for T/R Modules for Phased Array Radar Systems**
 - ONR Contract with: ACI MANTECH Center
 - Goal – Technical evaluation of available packaging technologies for phased array radar system T/R modules.
- **Sub Ambient Cooling System (SACS)**
 - SMDC BAA Contract With: Touchstone. Touchstone funding Raytheon for system development
 - Goal – Develop and test proof of concept High heat flux sub-ambient cooling system for Radar T/R integrated modules.
- **Silicon Carbide (SiC) MMIC Producibility Enhancement Program**
 - ONR Contract with CREE Research
 - Goal – Establish a foundry capability for affordable, reliable, high-performance SiC based devices and MMICs for BMDS Radars
- **High Voltage GaAs Producibility Program**
 - ONR Contract with Triquint, Inc.
 - Goal – Develop high voltage, high power density, X-Band pHEMT devices and MMIC amplifiers
- **RF Device Reliability Test Program**
 - NRL Reliability Testing Program
 - Goal – Independent DoD reliability testing/verification of power amplifier discrete devices, MMICs and packaged transmit/receive modules.
- **GaN Epitaxy Producibility Program**
 - Contract TBD FY06
 - Goal – Develop a producibility program for GaN epitaxial layers used for BMDS X-band radar power amplifier discrete devices, MMICs, and packaged transmit/receive modules.
- **Advanced Optical Processor (AOP) Lexington Development (LexDev) Interface test and ALCOR operational test.**
 - NAVAIR Contract with: Essex Corp.
 - Goal – Prove operation and data collection by testing the AOP while installed in the LL/MIT LexDev. Operational data collection and analysis with AOP installed in ALCOR on Kwajalein Atoll.
- **Sub Ambient Cooling System (SACS)**
 - SMDC BAA Contract With: Touchstone. Touchstone funding Raytheon for system development
 - Goal – Develop and test proof of concept High heat flux sub-ambient cooling system for Radar T/R integrated modules.



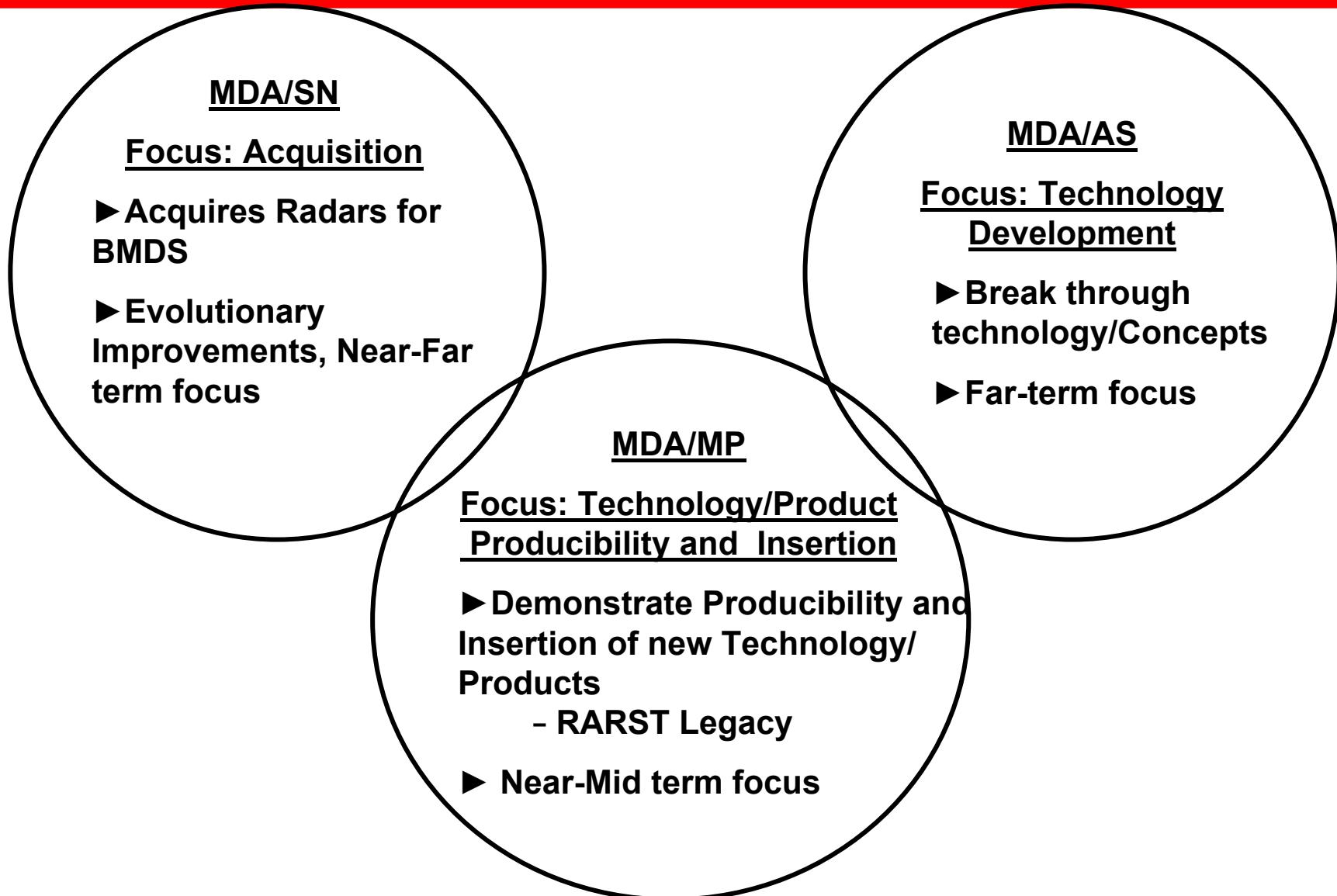
MDA/MP MAJOR ACCOMPLISHMENTS

- Major Player In MDA's SBIR Program To Enable More Rapid Transitions Of New Capabilities
 - 02.1 Announcement: 55 Phase I Awards, 29 Phase II Invitations Supported By MP
 - MP Topics In 02.2 Announcement: 51 Phase I Awards
 - Follow Up On 55 Phase II Initiatives Putting Many Small Firms In Direct Contact With Primes
 - MP Awarded The First Phase III At MDA (AOP)
 - Phase III recently awarded to V Systems
 - Network Of Primes And Major Subcontractors Established To Promote Relationships And Provide Opportunities With Small Businesses
- MP Furnishes Leadership, Seed Money, Cost Sharing And SBIR Strategy To Promote Producibility, Manufacturability, And Affordability Goals

Activities Are Paying Off With Selected SBIR Companies Making Prototype Hardware For SM-3, THAAD, And EKV



MDA Radar Stakeholders





Technology Insertion Candidates

- Wide Band Gap (WBG) High Power Amplifiers—Reliable SiC, GaN, and High Voltage GaAs Amplifiers for 2x-5x Performance Enhancement
- Advanced Thermal Management--Supports Higher RF Peak Power Levels using Active (2-Phase)/Passive(Pyrolytic Graphite)
- New Architectures for Antenna Hardware—Alternative T/R Module/TRIMM designs/Antenna Structure to Lower Production Costs and Weight (Enhance Transportability)
- Open Systems Architecture for Backend Electronics--Fosters COTS utilization, Object Oriented Software, Flexible Waveforms and Innovative Signal Processing
- Signal Processing Improvements—New Optical Processor for Real Time High Instantaneous Bandwidth Signal Processing

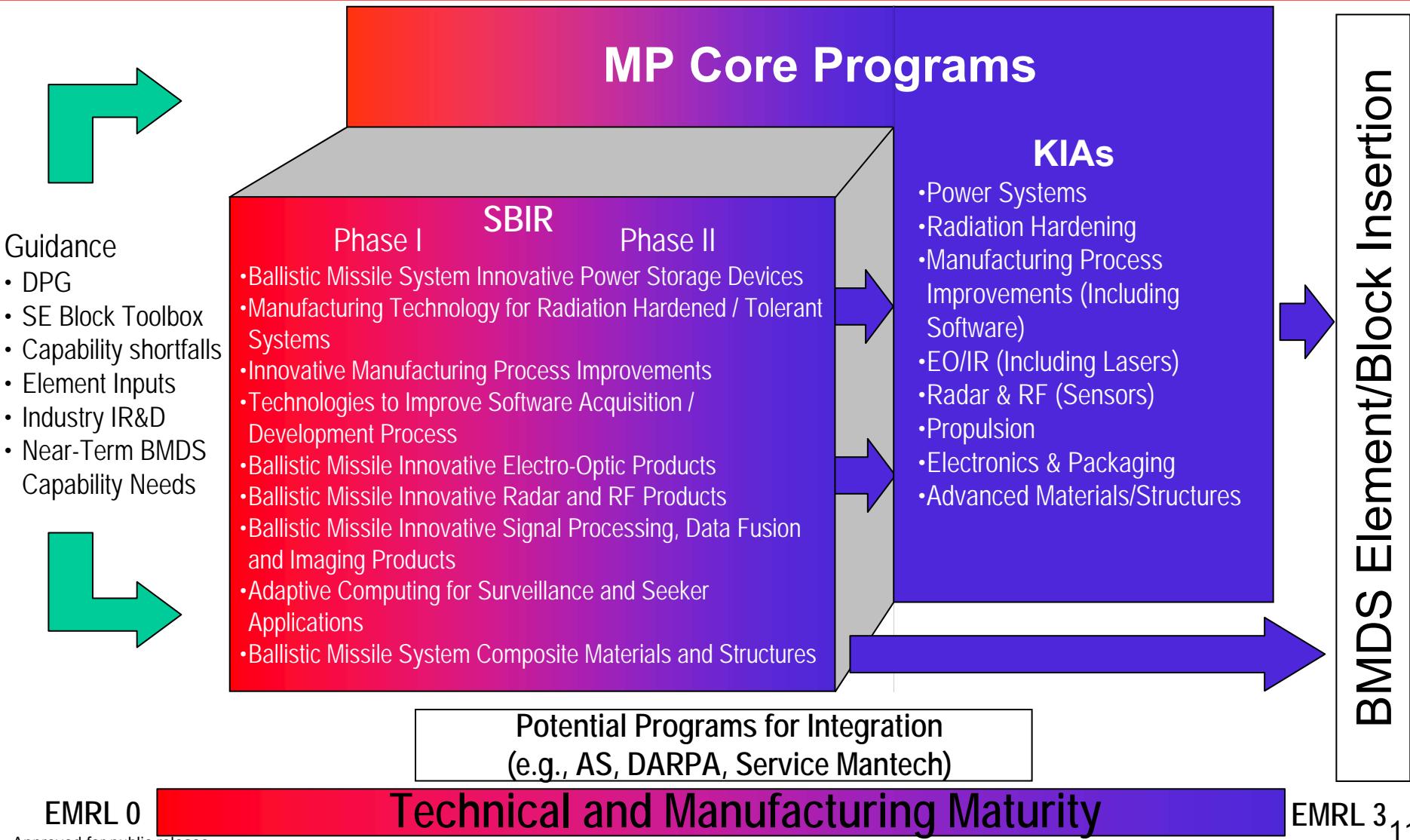


Utilizing Small Businesses

- MP Has as Excellent Track Record of Involving Small Business with Raytheon, Lockheed-Martin, Northrop-Grumman and other Major Companies in a number of Vital Areas (e.g., Industry Days)
 - High Power Amplifiers
 - Advanced Thermal Management
 - Alternative Packaging Techniques
 - Light-Weight Antennas/Heat Exchangers
 - Alternative T/R Module/TRIMM Designs
 - OS Approaches to Backend Electronics
 - Waveform Agility (PRN/Chaotic Codes)



Key Investment Area (KIA) Process





Industry Days



MDA/MP Industry Days

•As of August 2005 a total of Sixteen Industry Day Events have been held

- The First Three were held in Crystal City, VA
 - February 2003, April, 2003 & May 2003
- Nine have been held at Prime Contractor Facilities
 - June, 2003: Raytheon IDS, Andover, MA
 - July, 2003: Raytheon Missile Systems, Tucson, AZ
 - September, 2003: Lockheed-Martin MFC, Dallas, TX
 - November, 2003: Lockheed-Martin NESS, Moorestown, NJ (in cooperation with NSWC-Crane)
 - December, 2003: Lockheed- Martin MFC, Orlando, FL
 - May, 2004: Lockheed-Martin, Sunnyvale
 - May, 2004: Raytheon, Tucson
 - June, 2004: Raytheon APC, Dallas, TX
 - October, 2004: Raytheon IDS, Woburn, MA
 - July 2005: Boeing, Anaheim, CA
 - August 2005: Northrop-Grumman, Baltimore, MD
 - August 2005: Sensis Corporation, Syracuse, NY
 - August 2005: Lockheed-Martin, Syracuse, NY

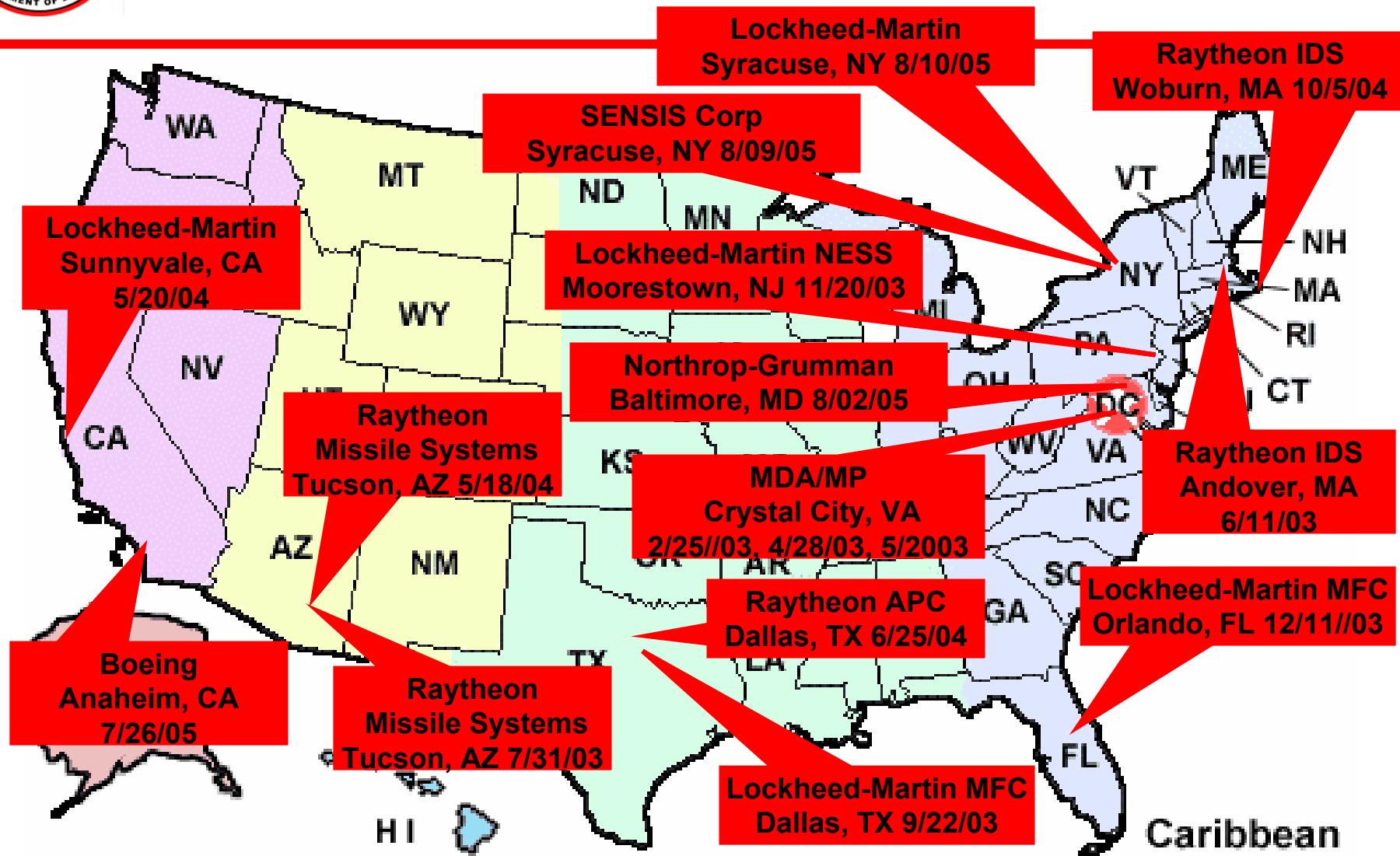


MDA/MP Industry Days Successes

- Industry Day has resulted in several significant events
 - Co-operative Agreement between Raytheon, Andover and Epitaxial Technology, Inc. (Baltimore, MD) for fabrication and testing of InP based HEMPTs
 - Adoption of MDA/MP industry Day format by AFRL, Kirkland AFB for SBIRs supporting ABL
 - Adoption of MDA/MP industry Day format by MDA/AS
 - Consideration of MDA/MP Industry Day format by the Chief Scientist MDA for use for an MDA wide Industry Day
 - Co-operation with NSWC Crane for inclusion of SBIR companies sponsored by MDA two-letters other than MP
 - Open discussions between numerous MP Sponsored SBIR companies and the prime contractors
 - Repeated interest in Thermal Management topics by the primes, Contracts with MMCC (Woburn, MA), Vanguard (Anahiem, CA), San Diego Composites (San Diego, CA)
 - Discussions between Harmonia and Raytheon, IDS for legacy software translation and re-use.



MDA/MP Industry Locations





RF Micro-Electronics Packaging



RF Micro-Electronics Packaging Study

- MP Program Objectives
 - Investigate State of the Market for RF Packaging Technology
 - Pursue COTS based solutions where possible
 - Investigate Existing and New RF Module Technologies
 - Evaluate Electronic, Thermal Management, RF, EMC, Cost and Producibility of each Technology/Combination of Technologies considered
- Results
 - Identified and evaluated candidate materials for high density, moduleless T/R module designs
- Insertion: Generally applicable to all Radar Systems



WBG Materials Program



Silicon Carbide (SiC) MMIC Productibility Enhancement Program (CREE)

- Joint Program with DARPA
- MP Program Objectives
 - To establish a foundry capability for affordable, reliable, high-performance SiC-based devices and MMICs for BMDS Radars. Cost Goal: \$10/mm. BMDS benefits include: 1, increased power (increased radar capability); 2, use less modules for same power, significant cost savings; and 3, use current power levels with same number of modules, resulting in increased life cycle reliability.
- Insertion: Navy AEGIS Radar (SiC), BMDS X-band Radars (GaN on SiC Substrate)
- Achieved 3" high purity, semi-insulating SiC substrates; Need 4" for GaN implementation for BMDS X-band radars (cost driver)
- 2006 Program Completion



Semi-Insulating SiC 4-inch Diameter Producibility Program (II-IV, Inc.)

POC: John Blevins; (937) 255-4474 X3210; John.Blevins@wpafb.af.mil

- Program Objectives
 - Produciblity program for 4-inch diameter semi-insulating SiC wafers used for power amplifier discrete devices, MMICs, and packaged transmit/receive modules. Develop multiple sources for SiC substrates. Three year program with Government cost goal of <\$1,000/wafer.
- Results
 - Nominal boule diameter for 6H and 4H crystals has been expanded to 4 inches with 3.5 inches useable area.
 - Vanadium doping for 6H has been optimized.
 - Q1 efforts yielded SiC substrates with micropipe density of 40/cm² (hero) and 60-70/cm² (typical) for 3.25 inch 6H.
- Insertion: BMDS Radars



High Voltage GaAs Program

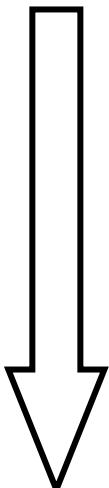


Example Cost Reduction/Performance Enhancement Opportunities

High Power Amplifier Outlook

Material	Pd (W/mm)	PAE (%)*	Insertion**	Company
GaAs	0.6	40	Current X-band Baseline	Raytheon, Triquint, MA/Com
MV GaAs	1.0-1.2	40	2005	Raytheon
HV GaAs	1.8	45	2006	TriQuint
LV GaN	3.5-5	40	2007	Raytheon, Others
HV GaN	5-7	40	2009	Raytheon, Triquint, Cree

NOW



Near Future
“Plan for it
Now”

LV-low voltage; MV-medium voltage; HV-high voltage

*Denotes MMIC-level efficiency

**Year at which a radar can be built with the HPAs. Passed proof of design and ready for production. Assumes radar system thermal management can handle the power density.



High Voltage GaAs Producibility Program

- Program Objectives
 - The program is a comprehensive research and development effort to achieve revolutionary, manufacturable, reliable, high voltage, high power density, X-band pHEMT devices and MMIC amplifiers with unsurpassed performance as compared with that achievable with the current pHEMT technology. The program goal is 2-3W/mm output power at the discrete device level.
- Results
 - Material experiments showing very promising results
 - Reliability data continues to look good
 - Delivered 60 functional EG7812s to China Lake
 - HV3-S variant performing at 24V and up to 30V
- Insertion: BMDS X-band Radars
- 2006 Program Completion



WBG Reliability Test Program



RF Device Reliability Test Program

- Program Objectives
 - Conduct 3rd-party, independent reliability testing/verification of power amplifier discrete devices, MMICs, and packaged transmit/receive modules. The purpose is to provide MDA's Radar procurement office with an independent government verification of Contractors Device reliability to support Technology Insertion recommendations.
 - Device testing conducted by NRL, NSWC-Crane, and Electro-Optics Center of Excellence
 - Devices include
 - Triquent x-band HV GaAs MMICs
 - 1st generation 28V GaN devices (DARPA Phase I Deliverables)
 - Will test DARPA Phase II Deliverables (x-band GaN discrete transistors from Raytheon/CREE, Triquent, Northrop Grumman)



Hybrid Opto-Electronic Signal Processor Maturation and Evaluation



Hybrid Opto-Electronic Signal Processor Maturation and Evaluation

- Program Objectives
 - The program is a comprehensive producibility effort to achieve a revolutionary, manufacturable, and reliable Hybrid Electro-Optical Signal processor. Present program effort towards proving operation and data collection by testing the AOP while installed in the LL/MIT LexDev. Operational data collection and analysis with AOP installed in ALCOR on Kwajalein Atoll
- Results
 - Advances in Sensor manufacturing showing very promising results
 - Calibration data continues to look good
 - Testing at LexDev scheduled for mid September 2005
 - Testing at ALCOR scheduled for January 2006
- Insertion: All BMDS Radars
- 2006 Program Completion



SUMMARY

- MDA/MP Radar Program Investing in a Number of Technologies and Approaches
 - WBG High Power Amplifier Producibility and Reliability
 - Advanced Thermal Management to support HPA Insertion
 - New Architectures for T/R Modules/TRIMMS to Enhance Thermal Management/Lower Cost
 - Active and Passive Heat Extraction at TRMM Level
 - Heat Exchangers at the System Level
 - Composite Materials to Reduce Antenna Weight/Enhance Thermal
 - System Engineering Approach from HPA to Ultimate Heat Sink (air/sea)